Comparative Perfonmance of Early and Late Maturing Nili Ravi Buffalo Heifers

A. N. Naqvi* and S. A. Shami[1]
Animal Sciences Institute, National Agricultural Research Centre, Islamabad, Pakistan-45500

ABSTRACT : Age at maturity was studied in 661 Nili Ravi buffaloes maintained at six dairy farms in Pakistan. The mean age at maturity in the overall data from the six farms was 976.49±9.2 days. Significantly lower mean age at maturity (957.93 ±10.68 days) was observed at Military Dairy Farm, Khyber Okara, Military Daiiy Farm, Punjnad and Livestock Research Station, National Agricultural Research Centre, Islamabad (Group I) compared to (1015.26±17.39 days) other three Military Dairy Farms, Peshawar, Nowshera and Rawalpindi (Group II). The advantages associated to early age at maturity were as following. Male and female calves were heavier (38.35±0.17 and 31.84±15 kg, respectively) in Group I as compared to (29.27 ±0.26 and 26.27±0.26 kg) in Group II. Milk yield per lactation was significantly higher in Group I (1912±12 lit.) as compared to (1833.36±16.56 lit.) in Group II . Lactation length was significantly longer (284.41±1.23 days) in Group I as compared to (277.77±2.02 days) in Group II. Dry period and service period were significantly shorter (241.59±4.18 and 217.05±4.95 days, respectively) in Group I as compared to (306.39±78 and 280.95±9.32 days) in Group II. The mean age at first calving and sex ratio were low (1282.75±10.14 days and 100 ♀♀:130.7 ♂♂) in Group I as compared to (1308.7±16.44 days and 100 ♀♀:152.15 ♂♂) in Group II but the differences were non significant. (*Asian-Aus. J. Anim. Sci. 1999. Vol. 12, No. 3 : 336-340*)

Key Words : Age, Maturity, Nili Ravi Buffalo, Pakistan

INTRODUCTION

Age at maturity affects the economics of dairy animals. Late maturity of heifers is known to be one of the main problems of dairy breeding in Pakistan. The age at maturity of buffaloes has been studied in various countries and the reports available described it as 1411.5 ±43.01 days in rural buffaloes of Bangladesh (Alam and Ghosh, 1993), 16 months in Jafarabadi×Murrah crossbreds in Brazil (Melo et al., 1991), 41.0±1.1 months in Kujang buffaloes in India (Dash and Mishra, 1990). The age at maturity averaged 31.8±1.1 months in Surti buffaloes (Govindaish and Rai, 1987), 1243.37± 236 days in Mehsana and Surti buffaloes (Tailor and Jain, 1988) and 1306.5 days (range 791-2166 days) in Rajistani buffalo in India (Aminudeen et al., 1986).

Age at maturity in Nili-Ravi buffalo in Pakistan was reported as 960±88 days (Ishaq and Shah, 1975) and 1064.4±9.7 days (Ahmed and Irfan, 1979).

Age at maturity can be reduced by improving feed and management practices or by selection among population (Chaudhry et al., 1983). Mineral and concentrate mixture along with green fodder reduces age at maturity (Chaudhry et al., 1991).

Supplementation of urea molasses mineral block lick to ammonia treated paddy straw reduces age at maturity in buffaloes (Garg et al., 1990).

Shade or cooling with water in summer reduces the age at maturity in buffaloes. Water cooling and wallowing reduces respiration rate and body temperature and it increases female fertility in summer (Das and Ray, 1991; Dollah et al., 1990).

* Corresponding Author: A. N. Naqvi.
[1] Department of Biological Sciences, Quaid-i-Azam University, Islamabad, Pakistan.
Received July 15, 1998; Accepted November 23, 1998

The present study was planned to investigate the age at maturity and its correlations with other traits of economic importance in Nili Ravi buffalo maintained at various farms in Pakistan.

MATERIALS AND METHODS

The study was based on 661 buffaloes maintained at following farms during the period 1978 to 1994.

Dairy Farms	No. of Buffaloes
Military Dairy Farm (MDF), Peshawar	30
Military Dairy Farm (MDF), Nowshera	86
Military Dairy Farm (MDF), Rawalpindi	98
Milltary Dairy Farm (MDF), Khyber Okara	187
Military Dairy Farm (MDF), Punjnad	217
Livestock Research Station, National Agricultural Research Centre (LRS, NARC), Islamabad	43
Total:	661

Buffaloes were kept in loose housing system with adequate supply of water at all the farms. In summer and autumn, in the morning times the buffaloes were taken out for grazing to the pastures for 2 to 3 hours.

At all the farms animals were fed concentrate ration according to their body requirements based on their production status along with green fodder and roughages. Usually six kilograms/day of concentrate ration was offered to milking buffaloes, two kilograms/day to pregnant and one kilogram/day to dry animals. The concentrate ration offered to the animals maintained at MDFs. Peshawar, Nowshera and Rawalpindi were convectional concentrates like oilseed cake+wheat or rice bran mixed with straw. Whereas, balanced feed containing 16 to 18% protein, 70 to 72% total digestible

nutrients and 2.5% minerals were offered at LRS, NARC, Islamabad and MDFs Khyber Okara and Punjnad. The ingredients of the feed and their replacements according to availability and economics are as following:

1) Cotton seed cake	10-25%
2) Rapseed cake or Maize oil cake	
3) Rice polish	25-60%
4) Rice bran or wheat bran	
5) Corn gluten feed	20%
6) Molasses	15-20%
7) Di-calcium phosphate or bone meal	2.5%
8) Sodium chloride	
9) Limestone	

Green fodder was available throughout the year in MDF Khyber Okara, Punjnad and LRS, NARC, Islamabad during the period under study. There was shortage of green fodder at MDFs. Peshawar, Nowshera and Rawalpindi. During these months the animals were generally fed on some silage and wheat straw.

Teaser bulls were let loose in the herd every morning and evening for detection of heat. The activity of the teaser bull was observed by the stock man. The heifers showing first heat were considered to be sexually mature.

Age of marutiry was earlier at MDF Khyber Okara, MDF Punjnad and LRS, NARC compared to MDFs Peshawar, Nowshera and Rawalpindi. The farms were thus, divided into two groups: Group I, early maturing (EM) and Group II, late maturing (LM). Birth weight, sex ratio, age at first calving, milk yield, lactation length, dry period and service period were studied in both early and late maturing groups.

Statistical analysis of the data involved analysis of variance, T-test and X^2-test following Sokal and Rohlf (1969) and Falconer (1981). To see the effects of season of calving on production traits in early and late maturing groups, the division of the year into four seasons (Winter, December to February; Spring, March to May; Summer, June to August and Autumn, September to November) was followed after Shah and Shah (1968).

RESULTS

The mean age at maturity in overall data from six farms was 976.49 ± 9.2 days. The age at maturity ranged from 855.6 ± 29.93 (LRS, NARC, Islamabad) to 1057.67 ± 52.76 days (MDF Peshawar) (figure 1). The buffaloes maintained at MDF Peshawar took significantly longer time in reaching age at maturity compared to those maintained at Livestock Research Station, NARC, Islamabad ($t_{(71)}$ = 3.33; p<0.01) (table2). The minimum and maximum age at maturity varied from 650 to 1836 days at MDF Nowshera; from 368 to 1586 days at MDF Peshawar; from 662 to 1541 days at MDF Rawalpindi; from 581 to 1863 days at MDF Khyber, Okara; from 537 to 1876 days at MDF Punjnad and from 559 to 1528 days at LRS, NARC, Islamabad. Lower mean age at maturity was observed at MDF Khyber Okara, MDF Punjnad and LRS, NARC, Islamabad (Group I) compared to other three military dairy farms, Peshawar, Nowshera and Rawalpindi (Group II). The buffaloes maintained at three former dairy farms reached age at maturity significantly earlier than those maintained at the other three farms ($t_{(659)}$ =2.81; p<0.01).

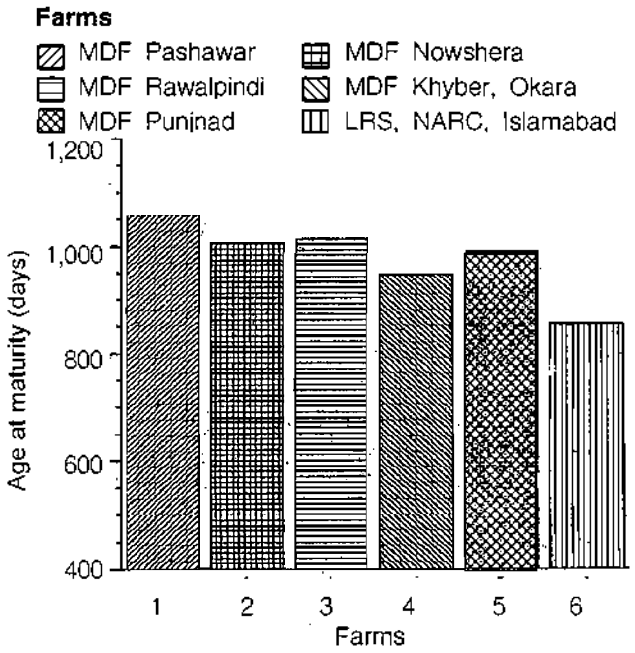

Figure 1. Age at maturity in Nili Ravi buffalo at different farms

The mean age at first calving in Group I (early maturing) was 1282.75 ± 10.14 days and in Group II (late maturing) it was 1308.78 ± 16.44 days. The difference between the two Groups was, however, not significant ($t_{(628)}$ = 1.34; p>0.10).

Higher birth weight was observed in males born in Group I (early maturing) compared to males born in Group II (late maturing) ($t_{(1185)}$ = 27.392; p<0.001).

Table 1. Age at maturity in Nili Ravi buffalo at various farms

MDF Peshawar	MDF Nowshera	MDF Rawalpindi	MDF Khyber,Okara	MDF Punjnad	LRS, NARC, Islamabad	Overall
1057.67 ± 52.76	1004.7 ± 28.16	1011.60 ± 24.05	945.56 ± 15.8	988.86 ± 15.77	855.6 ± 29.93	976.49 ± 9.2
(30)	(86)	(98)	(187)	(217)	(43)	(661)

F = 4.49 ; p<0.001.

Table 2. Characteristics of early (I) and late (II) maturity groups in Nill Ravi buffalo

	Goup I	Group II	Significiance
Age at maturity (days)	957.93±10.68 (447)	1015.26±17.39 (214)	$t_{(659)}$ =2.81; p<0.01
Age at Ist calving (days)	1282.75±10.14 (423)	1308.78±16.44 (207)	$t_{(628)}$ =1.35; p>0.2
Birth weight of males (kg)	38.35±0.17 (1148)	29.79±0.27 (439)	$t_{(1187)}$ =27.39; p<<0.001
Birth weight of females (kg)	31.84±0.15 (877)	26.27±0.26 (292)	$t_{(1167)}$ =8.16; p<<0.001
Sex ratio (males against 100 females)	100:130.76 (910):(1190)	100:152.15 (318):(485)	$X^2_{(1)}$ =3.31; p>0.05
Tatal milk yield (litters)	1912.00±12.00 (1901)	1833.36±16.56 (652)	$t_{(2551)}$ =3.84; p<0.001
Lactation length (days)	284.41±1.23 (1901)	277.77±2.02 (652)	$t_{(2551)}$ =2.81; p<0.01
Daily milk yield (litres)	6.72±0.03 (540670)	6.60±0.21 (181104)	$t_{(721772)}$ =0.415; p>0.05
Dry period (days)	241.59±4.18(1584)	306.39±8.78(592)	$t_{(2174)}$ =6.67; p<0.001
Service period (days)	217.05±4.95 (1304)	280.96±9.32 (617)	$t_{(1919)}$ =6.06; p<0.001

Table 3. Effect of season of calving on production traits in early (Ⅰ) and late (Ⅱ) maturity groups

	Group I			Group II		
	Winter+Spring	Summer+Fall	Significance	Winter+Spring	Summer+ Fall	Significance
Birth weight (kg)	36.05±0.25 (660)	35.20±0.16 (1365)	p<0.01	28.42±0.34 (236)	28.33±0.26 (496)	NS
Male birth weight (kg)	39.18±0.28 (386)	37.90±0.19 (762)	p<0.001	29.81±0.43 (150)	29.71±0.35 (289)	NS
Female birth weight (kg)	31.64±0.29 (274)	31.79±0.19 (603)	NS	26.00±0.45 (86)	26.24±0.37 (206)	NS
Sex ratio (males against 100 females)	141.43 (280:396)	116.51 (630:794)	p<0.05	171.72 (99:170)	143.83 (219:315)	NS
Total milk yield per lactation (lit.)	1990.32±19.94 (598)	1874.40±14.67 (1303)	p<0.001	1884.51±29.46 (199)	1811.14±19.85 (453)	p<0.05
Lactation length (days)	285.18±2.00 (598)	284.28±1.48 (1303)	NS	271.91±3.25 (199)	280.21±2.55 (453)	p<0.05
Daily milk yield (lit.)	6.98±0.29 (170536)	6.59±0.19 (370419)	NS	6.93±0.50 (54110)	6.46±0.31 (126935)	NS
Dry period (days)	255.89±7.27 (511)	234.03±5.08 (1073)	p<0.02	343.23±15.98 (189)	289.35±10.41 (403)	p<0.01
Service period (days)	243.80±8.86 (408)	204.49±5.93 (896)	p<0.001	306.91±16.80 (184)	269.98±11.20 (433)	NS

Similarly, higher birth weight was observed in females born in Group Ⅰ (early maturing) compared to females born in Group Ⅱ (late maturing) ($t_{(1167)}$=18.159; p<0.001).

In Group Ⅰ (early maturing) sex ratio (100 ♀♀: 130.76 ♂♂) was lower than in Group Ⅱ (late maturing (100 ♀♀: 152.15 ♂♂), but the difference between the two Groups was not significant (X^2(1)= 3.31; p>0.05) (table2). In Group Ⅰ (early maturing) the mean milk yield per lactation was 1912.00±12.00 lit. and Group Ⅱ (late maturing) it was 1833.36±16.56 lit. The milk yield per lactation was significantly higher in Group Ⅰ (early maturing) ($t_{(2251)}$ = 3.84; p<0.001).

In Group Ⅰ (early maturing) mean lactation length was 284.41±1.23 days and in Group Ⅱ (late maturing) it was 277.77±2.02 days. The buffaloes maturing at an early age (Group Ⅰ) showed significantly longer mean lactation lengths than those maturing late (Group Ⅱ) ($t_{(2251)}$=2.80; p<0.01).

Mean daily milk: yield in Group Ⅰ (early maturing) was 6.72±0.03 and in Group Ⅱ (late maturing) it was 6.6±0.21, however, the difference in milk yield per day in the two Groups was not significant ($t_{(721772)}$=0.415; p>0.05).

Mean dry period in Group Ⅰ (early maturing) was 241.59±4.18 days and in Group Ⅱ (late maturing) was 306.39±8.78 days. Buffaloes reaching age at maturity late went for significantly longer dry period compared to those reaching age at maturity early ($t_{(2174)}$=6.67; p<0.001).

Mean service period in Group Ⅰ (early maturing) was 217.05±4.95 days and in Group Ⅱ (late maturing) 280.96±9.32 days. Late maturing buffaloes showed significantly longer service period compared to early maturing buffaloes ($t_{(1919)}$=6.05; p<0.001).

Production traits were more effected by season of calving in Group Ⅰ as compared to Group Ⅱ (table3). In Group Ⅰ male birth weight, sex ratio and total milk yield were significantly high and dry period and service period were significantly longer in winter and spring calvings as compared to summer and fall calvings. In Group Ⅱ significant effect of season was seen on total milk yield, lactation length and dry period (table3).

DISCUSSION

The mean age at maturity of buffaloes in this study

ranges from 855.6±29.93 to 1057.67±52.76 days (table 1). The age at maturity reported far buffaloes from other countries is one the higher side. Bangladeshi rural buffaloes take 1411.51±43.01 days (Alam and Ghosh, 1993); 48 months (Faruque, 1995) to reach age at maturity. Kujang buffaloes in India take 41.0±1.1 months (Dash and Mishra, 1990); Mehsana and Surti buffaloes take 1243.37±23.6 days (Tailor and Jain,1988) and Rajasthani buffaloes take 1306.5 days (Amin-ud-Deen et al., 1986) to reach age at maturity. However, Surti buffaloes from Bangalore take 31.8±1.1 months to reach age at maturity (Govindaish and Rai, 1987). This is less than what has been observed in this study. Melo et al. (1991) observed even shorter age at maturity (16 months) in crossbreds from Jafarabadi×Murrah in Brazil. Salama et al. (1994) observed age at maturity 15.41± 0.8 months in Egyptian buffalo.

Other studies carried out in Pakistan show variation in age at maturity ranging from 530 to 2130 days In buffaloes from Faisalabad (Ahmed and Irfan, 1979). Ishaq and Shah (1975) reported age at maturity as 960 ±8.8 days in Nili-Ravi buffaloes from Bahadurnagar Okara. Their findings are comparable to age at maturity at MDF Khyber Okara (945.56±15.8) in this study.

On the basis of age at maturity, two groups i.e. early maturing (Group I) and late maturing (Group II) are farmed. In Group I the age at maturity is 957.93± 10.67 and in Group II it is 1015.26±17.39. Group I sexually matures significantly earlier than Group II ($p<0.01$).

Advantages associated to early age at maturity (Group I) compared to late maturing buffaloes (Group II) indicate that male and female calves are significantly heavier ($p<0.001$); milk yield per lactation is higher ($p<0.001$) and lactation length is significantly longer ($p<0.001$) in Group I than in Group II. Group I has shorter dry period ($p<0.001$) and service period ($p<0.001$) as compared to Group II (table 2).

Age at first calving in Group I is lower than Group II, males produced in Group I are less than in Group II but both these traits show non-significant differences. Daily milk yield is also non-significantly higher in Group I compared to Group II.

In combined data and in male calves the birth weight increases as the number of parity increases in sexually early maturing (Group I) but a decrease in birth weight is observed in late maturing (Group II). In female calves significant negative trend in birth weight is observed in Group II ($b = -0.31$; $F(1,5)=9.11$; $p<0.05$) and non-significant positive trend is seen in Group I (early maturing). Similar trend is seen by Shami and Azra (1980) in human. They report that lighter males are born to younger mothers than the females in a human population of Punjab.

Non-significant effects of parity are also observed on sex ratio, total milk yield and daily milk yield in Group I and Group II buffaloes. However, parity shows significant decrease in dry period ($p<0.05$) and service period ($p<0.05$) in Group I buffaloes. Lactation length in Group I shows highly significant negative trend with increase in parity ($p<0.01$).

Chaudhry et al. (1983) reported the effect of feeding on growth rate, age and weight at maturity and age at first calving in Sahiwal, Friesian×Sahiwal crossbred cattle and Nili-Ravi buffaloes. Each type of animals was divided into two groups. The one which was offered concentrate mixture (1% of live weight bases) along with green fodder *ad libitum* and the other group which was offered green fodder alone. The information reveals that the animals which were offered concentrate mixture+green fodder had a higher daily growth rate, lower age at maturity and lower age at first calving compared to the other group.

Asghar et al. (1983) reported that concentrate feed containing 15% crude protein and 64.9% total digestible nutrients in addition to green fodder increased growth rate, 0.77±0.09 kg per day compared to 0.50±0.14 kg per day in case of green fodder only. The reduction in age at maturity was also observed, 736.5±76.14 against 866.33±131:36 days in the animals which were offered green fodder only.

Chaudry et al. (1991) reported that green fodder+ concentrate and mineral supplement reduce the age at first calving (1045 days) in Nili-Ravi buffaloes as compared to green fodder+concentrate (1053 days) and green fodder (1472 days).

Kumar et al. (1992) reported effect of supplementation of yeast culture (*Sacharomyces cereviscae* plus growth medium) in diet of buffaloes on milk yield and composition. Average daily milk yield increased proportionally by 0.135 with the inclusion of yeast. Fat, protein lactose and total solids in milk increased proportionally by 0.039, 0.051, 0.03 and 0.034, respectively.

Garg et al. (1990) reported the effect of supplementation of urea molasses, mineral block lick to untreated or ammonia treated paddy straw on age at maturity in Surti buffaloes. Age at maturity was found to be 23 and 21 months in untreated and ammonia treated straw, respectively. Khurana et al. (1996) reported 5% increase in milk yield with the feeding of herbal *galactagogul payapro* in lactating buffaloes of Hisar, India.

Shrestha et al. (1992) reported the effect of mineral supplementation on milk yield in Nepali buffaloes. They reported that the milk yield is significantly higher in animals which were provided 66 grams salt lick supplementation (containing 88% NaCl and traces of iron iodine, copper, magnesia and cobalt) mixed with Khole (vegetable waste).

The influence of feed has been observed in this study as well. In MDFs peshawar, Nowshera and Rawalpindi the animals are fed on oil seed cake wheat or rice bran mixed with straw. In these three farms the age at maturity ranges from 1004.7±28.16 to 1057.67± 52.76 days. In MDF Khyber Okara, MDF Punjnad and LRS, NARC, Islamabad a balanced feed is offered containing 16-18% protein, 70 to 72% total digestible nutrients and 2.5% of minerals. Moreover, green fodder is available *ad libitum*. In these farms the age at maturity ranges from 855.6±29.93 to 988.86±15.77 days.

In Group I male birth weight, sex ratio and total milk yield were significantly high and dry period and service period were significantly longer in winter and spring calvings as compared to summer and fall calvings. In Group II significant effect of season was seen on total milk yield, lactation length and dry period (table 3).

The biological reasons for the seasonal effect (on milk yield) are as following. An animal calving in spring or winter has a better environment generally in her initial period of lactation because of relatively low environmental temperature and abundance of green fodder. So the main causes of reduced milk production in summer and fall seasons are primarily attributed to the nutritional status of the animals and their inability to dissipate heat fast enough.

The better reproductive efficiency (low dry and service periods) in summer and fall calvers is understandable as the summer calvers are soon entering to the autumn season which is the breeding season for the buffaloes and in this season fertility is better than in other seasons. Those buffaloes calving in winter and spring which did not show first post partum oestrus within these seasons enter in to the summer season. The buffaloes oestrus frequency in summer is minimum therefore, summer anoestrus will contribute considerably to the interval "parturition to first service" to buffaloes calving in winter+spring seasons. Applications of oestrus induction and oestrus synchronization in the open buffaloes of winter and spring seasons would be useful managemental tool for improvement of the herd's fertility.

Among the various causes of late age at maturity two factors seem most important that is a defective overall management or the inability of a particular animal to grow and develop fast enough to attain early sexual maturity. Early maturing buffaloes must be different genetically from late maturing buffaloes. Non genetic factors were available in terms of feed. In late maturing buffaloes concentrate feed was oil seed cake, wheat or rice bran mixed with straw, while in early maturing buffaloes balanced concentrate feed containing 16-18% protein, 70 to 72% digestible nutrients and 2.8% minerals plus abundance of green fodder was fed. This is just possible that conditions of management for early maturing buffaloes may be favourable for the expression of genes as compared to late maturing buffaloes. It can also be suggested from the results that there could be a better genetic setup in early maturing buffaloes compared to late maturing buffaloes. This places the former group to the advantage of breeders.

REFERENCES

Ahmad, N. and M. Irfan. 1979. Studies on reproductive efficiency of Nili-Ravi buffaloes. Post-graduate Research in Vet. Sci. Univ. of Agriculture, Faisalabad: 137.

Alam, M. G. S. and A. Ghosh. 1991. Reproductive patterns of rural buffaloes (*Bubalis bubalis*) in Bangladesh. Proceedings. Third World Buffalo Congress, Varna Bulgaira. III: 683-685.

Amin-ud-Deen, R. K. Tanwar, L. S. Jain, S. P. Tailor and M. Singh. 1986. Observations on reproductive traits of buffaloes. Livestock Advisor. 11(11):19-23.

Asghar, A. A. and J. Iqbal. 1984. Stay on correlation between liveweight and age at first conception in buffalo heifers. Fifth Annual Report. Directorate of L.P.R.I., Bahadurnagar, Okara: 91-93.

Chaudhry, M. A., S. I. Haider, M. Ahmed and G. Rasool. 1983. Effect of concentrate feeding on growth rate, age and weight at puberty/first claving and milk production in Sahiwal, Friesian X Sahiwal crossbred and Nili-Ravi buffalo heifers. Fourth Annual Report, Directorate of L. P. R. I. Bahadurnagar, Okara: 88-90.

Chaudhry, M. A., A. A. Asghar and M. Ahmed. 1991. Productive and reproductive performance of Nili-Ravi buffalo heifsrs as influenced by mineral and concentrate mixture. Buffalo Journal. 7(1)41-49.

Das, S. K. and S. K. Ray. 1991. Effect of cooling on performance of buffaloes. Livestock Advisor. 16(9):16-21.

Dash, T. and M. Mishra. 1990. Characteristics and performance of Kujang buffaloes, Ind. J. of Anim. Prod. and Management 6(4):207-212.

Dollah, M. A., N. Ramakrishman, Y. Nordin and R. A. Sani. 1990. Reproductive responses to climatic heat induced by management systems in swamp buffaloes. Proceedings of the final research coordination meeting on the use of nuclear techniques to improve domestic buffalo production in Asia. Phase-II Rockhampton, Australia. Organized by the joint FAO/IAEA Division of Nuclear Techniques, Food and Agriculture, Vienna. 155-166.

Falconer, D. S. 1981. Introduction to quantitative genetics. Second Edition. Longman Group Limited, London, U.K.

Faruque, M. O. 1995. Indigenous buffaloes in the coastal area of Bangladesh. Buffalo Newsletter. 4:3-5

Garg, M. R., A. K. Tripathi and P. J. G. Kunju. 1990. Effect of supplementing urea molasses mineral block lick to untreated or ammonia treated paddy straw on economics of weight gain and age at maturity in buffalo calves. Ind. J. of Animal Nutrition. 7(1):55-58.

Govindaish, M. O. and A. V. Rai. 1987. Productive and reproductive traits of medium size buffaloes. Ind. J. of Dairy Sci. 40(2):333-337.

Ishaq, S. M. and S. K. Shah. 1975. Comparative performance of Nili-Ravi buffaloes and Sahiwal cows as dairy animals. Agri. Pakistan. 26(1):75-88.

Melo, M. I. V., V. R. Vale-Filho and E. F. Nascimento. 1991. Body weight, Scrotal circumference and development of spermatogenesis in crossbred buffaloes at the ages of 10 to 24 months. Cab. Animal Breeding Abstracts, 1992. 060-00218.

Salama, M. A. M., E. M. Mokhless and A. H. Barkawi. 1994. Pubertal Performance of Egyptian buffalo heifers. Buffalo Journal. 10(1):61-66.

Shah, N. H and S. K. Shah. 1968. Seasonal influence on oestrus incidence and conception rate in buffaloes. Pak. J. Agri. Sci. 5(3-4):222-227.

Sokal, R. R. and F. J. Rohlf. 1969. Biometry W. H. Freeman and Company, San Fransico.

Shami, S. A. and A. Khan.1980. Maternal age and parity effects on human birth weight: A hospital survey from Lahore (Punjab), Pakistan. J. P. M. A. 30(6):131-137.

Tailor, S. P. and L. S. Jain. 1988. Genetic study on breeding efficiency of medium size buffaloes. Ind. J. of Diary Sci. 41(2):215-216.